Recent invasions of World Heritage rainforests in north-east New South Wales by the cane toad *Bufo marinus*

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ABSTRACT

The cane toad *Bufo marinus* is well recognised as a threat to biodiversity in northern Australia. Concern about this impact has grown in recent years as the species spreads geographically. Previous estimates of the potential distributional limits of *B. marinus* have excluded high elevation rainforest, largely based on thermal tolerances and known habitat preferences. This paper reports on the detection of B. marinus over a five-year study in the Border Ranges National Park in northern NSW. More than 400 toads were detected in rainforests at elevations between 810 m and 1130 m, with all captures being made along an isolated section of road within the reserve. No breeding was observed, all captures were of adults and nearly all appeared to be female. The indications are that toads migrated through heavily forested steep escarpment to the east, rather than along the road network and thus represent a significant emerging threat to the entire reserve. Models predicting the distributional limits of *B. marinus* will need to consider a broader range of elevations, habitat types and thermal tolerances than has been previously considered. Further research is urgently required to understand the threat this invasion may pose to the unique biodiversity of this World Heritage Area and attempt to mitigate the threat.

Key words: cane toad, *Bufo marinus*, Border Ranges, World Heritage, rainforest, frog.

Introduction

The cane toad *Bufo marinus* is a large, toxic amphibian that is native to central and southern America (Zug and Zug 1979). It has been translocated widely, both deliberately (Mungomery 1936; Covacevich and Archer 1975) and inadvertently (van Beurden and Grigg 1980; Seabrook 1991) and is thought to be one of the most widespread terrestrial vertebrates on the planet (Sabeth *et al.* 1981). Its introduction into Australia poses a significant risk to elements of biodiversity that feed on frogs, due to its toxicity (Covacevich and Archer 1975; Burnett 1997; Phillips *et al.* 2003; Doody *et al.* 2006; Griffiths and McKay 2007; Doody *et al.* 2009) and to invertebrate diversity due to its voracious feeding habits (Greenless *et al.* 2006). However, State and Federal governments have only recently formally acknowledged its detrimental impacts.

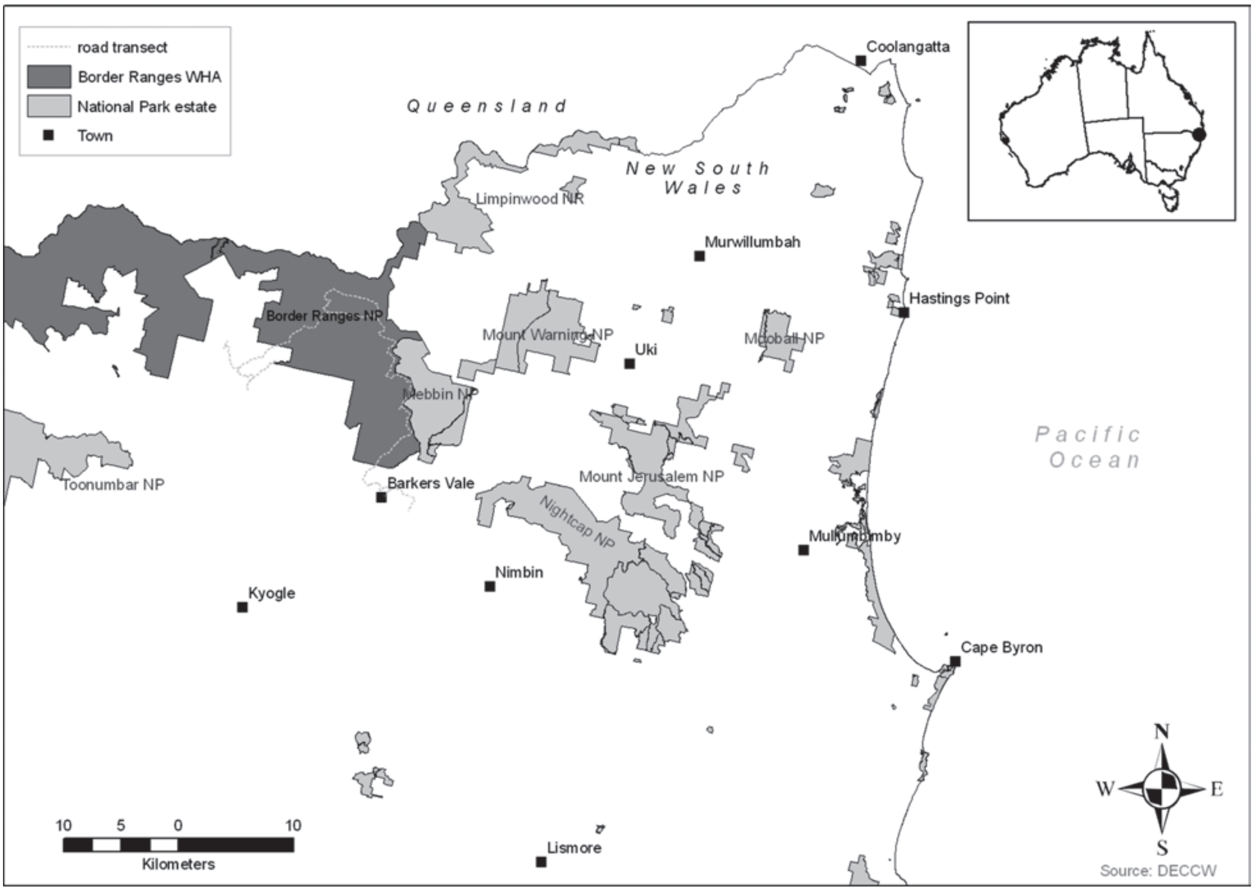
The distribution and abundance of *B. marinus* within Australia has rapidly increased since the initial importation of 101 toads into Queensland in 1935 and the subsequent captive breeding and translocation by the Queensland Cane Grower's Federation (Mungomery 1936). The northern spread of *B. marinus* has occurred more rapidly than in the south, perhaps due to biophysical factors that limit breeding periods, thermal constraints that affect locomotor performance (Phillips *et al.* 2006) and because of differences in the suitability of available habitat types (Urban *et al.* 2008). As a consequence, many of the high conservation value forests of northern New South Wales have remained free of this pest species, until relatively recently.

This paper reports on recent records of *B. marinus* from high elevation rainforests of the Border Ranges World Heritage Area. The aim of the study was to document the distribution and relative abundance of *B. marinus* in the reserve, whilst conducting removal to control their spread. The Border Ranges forms a substantial part of a 'biodiversity hotspot' that is recognised as the most biologically diverse region within NSW (DEWR 2007). I use the information gained to highlight the potential for the cane toad to impact on the diverse fauna of the area and stress the urgency in managing this pest species in the region.

Methods

The study area

The Border Ranges National Park (31 860 ha) is located in far northern New South Wales and connects with Mebbin National Park to the east and Limpinwood Nature Reserve to the north (Figure 1). The reserve is also contiguous with Lamington National Park in southeast Queensland. The region is of great biological significance and provides habitat for a large number of species that are of conservation concern (DECC 2008). Many of these species have highly restricted geographical distributions and specialised ecological requirements. Of particular note, the region supports one of the highest diversities of amphibians in Australia and a highly significant population of the endangered Fleays' barred frog *Mixophyes fleayi* occurs within the



Source: DECCW

Figure 1. Location of the Border Ranges World Heritage Area in far northern NSW and the road transect.

Border Ranges (Goldingay *et al.* 1999). The reserve is listed as a World Heritage Area, in recognition of its outstanding biodiversity values.

This work was undertaken in the eastern section of the Border Ranges World Heritage Area along the Tweed Scenic Road, from the Sheepstation Creek entrance to the Creegans Road exit and incorporated the Brindle Creek loop road. The study area is characterised by cool temperate and sub-tropical rainforests, with some minor areas of wet sclerophyll forest at lower elevations. The road transect covers an elevational gradient of between 400 and 1130 m asl.

Survey and collection

Targeted surveys for *B. marinus* were undertaken each month between December and March, over five summers (2005 – 2010). Initial surveys in 2005-2006 were less intensive than subsequent years. An attempt was made to survey over a minimum of three consecutive warm and wet nights, because it was likely that toad activity would be influenced by climatic variation. In the event that few (<2) toads were active on the first night, the subsequent nights of survey were delayed (up to 3 weeks). This was largely determined by climate, however, logistics sometimes made consecutive surveys difficult or impossible (tree falls, floods and road closures).

I conducted the surveys by slowly driving along roads (ca. 15-20 km/h) at night and capturing any toads that were active on the road surface or visible along the road verge. There were 62 nights of survey in total and on the majority of visits (44), I drove the 42 km road transect in both directions (84 km) between 2000 h and 0400 h.

Surveys at water-bodies (farm dams) adjoining the reserve were also undertaken in order to determine the proximity of *B. marinus* to the start and finish of the road transect. These surveys utilised call playback to elicit a response from male toads and consisted of two minutes of call broadcast followed by a 5-minute listening period. Additional information regarding the distribution of *B. marinus* was collected by informally questioning residents in areas adjacent to the reserve and also by locating active toads on roads outside of the reserve. It was initially thought that the road network provided the most likely avenue for *B. marinus* entering the reserve.

Bufo marinus was captured in individual plastic bags and information on body size, weight and sex of each individual was collected. Sex was determined by the presence /absence of nuptial pads and by colouration of the dorsal surface and throat region. Females appear to be heavily mottled and have a dorso-lateral stripe, while males are uniformly brown. The position of individuals was plotted using a Global Positioning System (Holux) connected to a handheld computer (HP Ipaq™). On a number of occasions an individual eluded capture. In such instances the position was recorded and in most cases a toad was located in the same location on the return drive. Toads were euthanised within 12 h of capture using immersion in AQUIS ™.

Results

Between December 2005 and March 2010 the road transect was surveyed 62 times and a total of 411 *B. marinus* was detected within the reserve. Of these, 371 (90%) were captured and removed. There was a sharp increase in the total numbers detected in the 2008-09 season (Figure 2) and activity generally peaked in February – March each year, when 57% of all individuals were detected.

Bufo marinus was found across an elevation gradient of 810-1130 m ASL within the reserve. There was a pattern in the mean elevation of captures between months (Figure 3) with toads being found at higher elevations later in the survey periods. Only one of the captures was classified as male as it had well developed nuptial pads and lacked a dorso-lateral stripe. This individual was found at Forest Tops camp ground in January 2010. All other captures were characterised

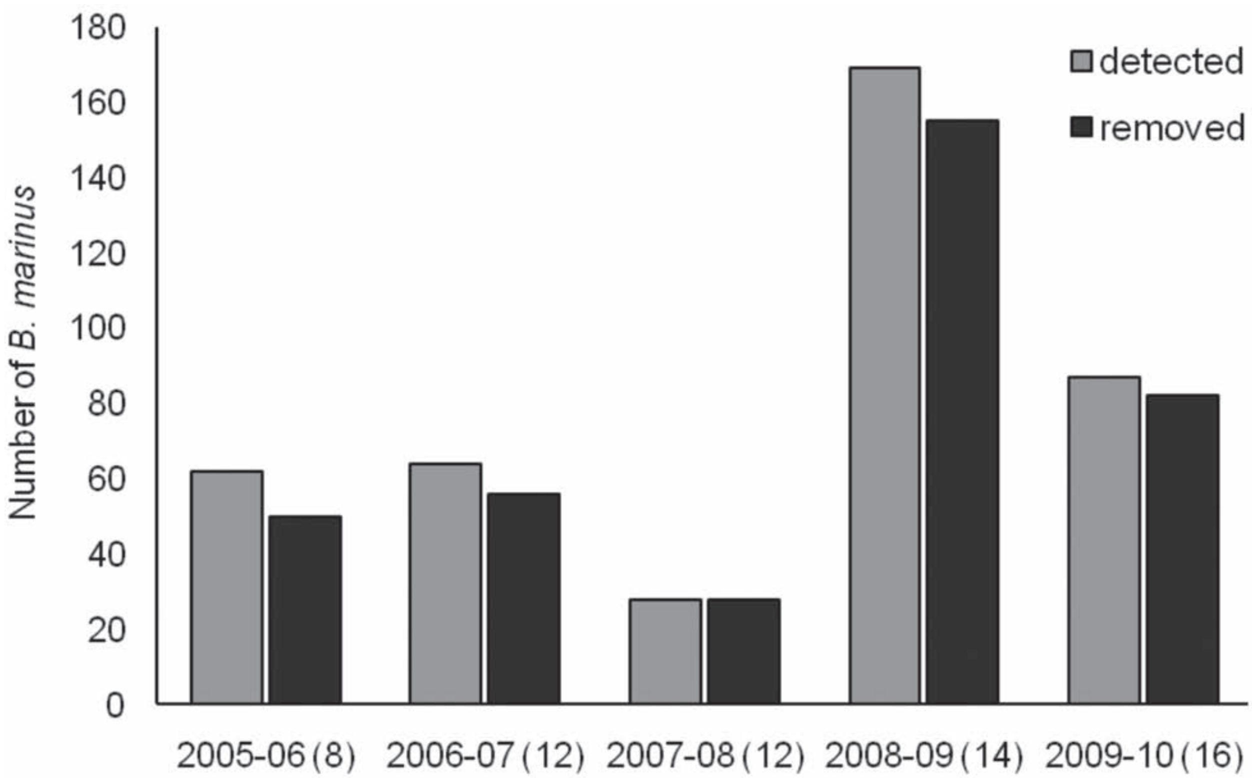


Figure 2. The number of Bufo marinus detected and captured between December 2005 and March 2010 in the eastern Border Ranges World Heritage area. Numbers in brackets indicate the number of survey nights.

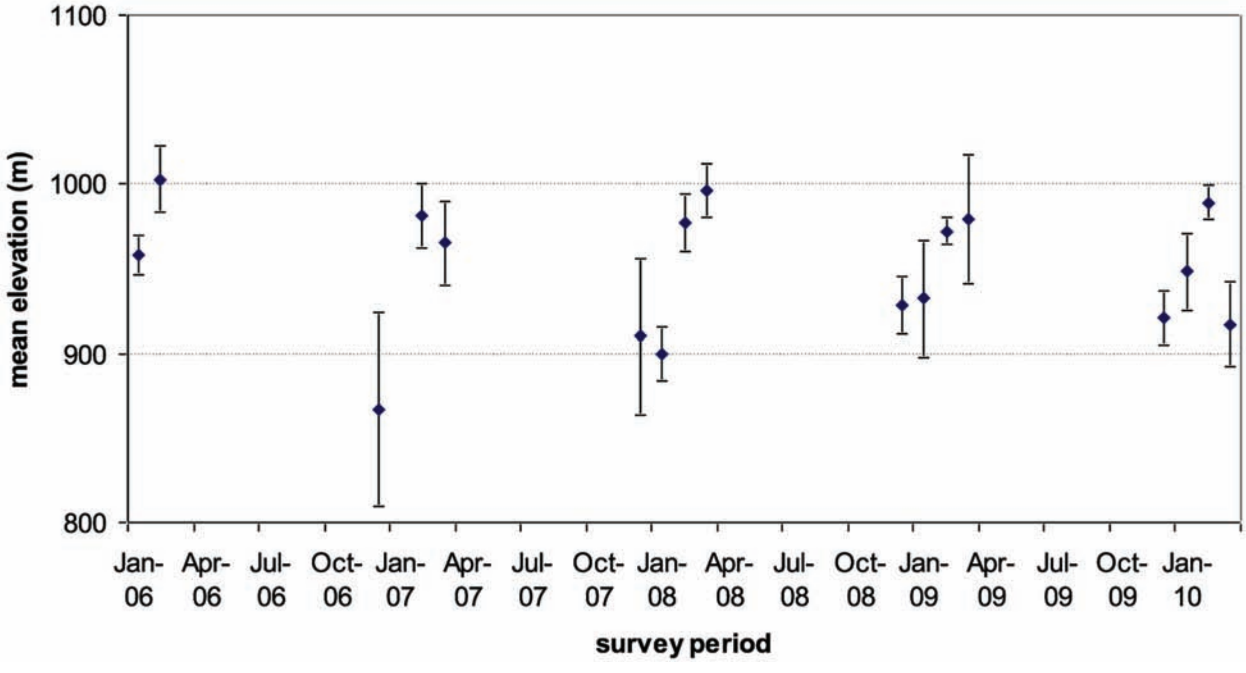


Figure 3. Mean elevations (+/- SE) of *Bufo marinus* captured in the Border Ranges World Heritage Area across four survey periods.

by mottled dorsal patterning, the presence of a dorsolateral stripe and a lack of discolouration of the throat. Individuals ranged in size from 55-120 mm (snout-urostyle length) and 38-320g.

The distance over which *B. marinus* was detected along the road within the reserve was restricted to approximately 18 km. *Bufo marinus* was not recorded from remaining areas of the reserve that were surveyed (Figure 4) with the exception of the single male at Forest Tops. The highest concentrations within the reserve were associated with the Tweed Valley and Blackbutts lookouts. The Tweed Valley lookout has no visitor infrastructure associated with it.

Discussion

These surveys have demonstrated that the vertebrate pest *Bufo marinus* now occurs within the World Heritage rainforests of the Border Ranges National Park and that they are able to migrate into high elevation rainforest (up to 1130 m asl). *Bufo marinus* was not previously known from high altitude rainforests and was considered unlikely to occupy this habitat type (Covacevich and Archer 1975; Seabrook and Dettmann 1996). Indeed, previous predictions of their potential distribution identified mountains, steep topography and dense forest as features that would serve as barriers to dispersal (Zug and Zug 1979; Esteal *et al.* 1985; Esteal and Floyd 1986; Seabrook 1991). Whilst these features may have served to slow dispersal (Urban *et al.* 2008) they do not appear to have acted as a barrier. Predictive models should now include a broader range of habitats and elevations than have been used previously, because it is apparent that *B. marinus* is able to occupy more extreme habitats than originally believed (Urban *et al.* 2007).

Cane toads in NSW

Bufo marinus has been present in northern New South Wales since 1964-66, when a founder population was established around the coastal community of Byron Bay (van Beurden and Grigg 1980). This population remained disjunct from the southern Queensland population as recently as 1980 (Esteal *et al.* 1985) however, by the early 1990s this disjuncture had closed and toads occupied the Tweed River valley west of Murwillumbah (Seabrook 1991). Smith *et al.* (1989) did not report the presence of *B. marinus* from any of the major rainforest blocks associated with the Mt Warning caldera during surveys of herpetofauna in the late 1980's. These surveys included the Border Ranges and this supports the notion that these invasions are a recent occurrence. Understanding how toads are entering these habitats will be important to the development of control options in order to mitigate the potential threat.

Roads are recognised as corridors for dispersal of *B. marinus* (Seabrook and Dettmann 1996; Brown *et al.* 2007). The road network within the study area would provide opportunities for *B. marinus* to enter the reserve. However, the evidence presented here (based on five consecutive seasons of survey) suggests this hypothesis is incorrect. More than 400 individuals have been detected since 2005 and their location is isolated by over 12 km to the north and south from lower elevation *B. marinus* that were detected on roads or at water bodies outside of the reserve. If roads were conduits for *B. marinus* at this location then it is likely that they would be detected throughout the reserve but this was not the case.

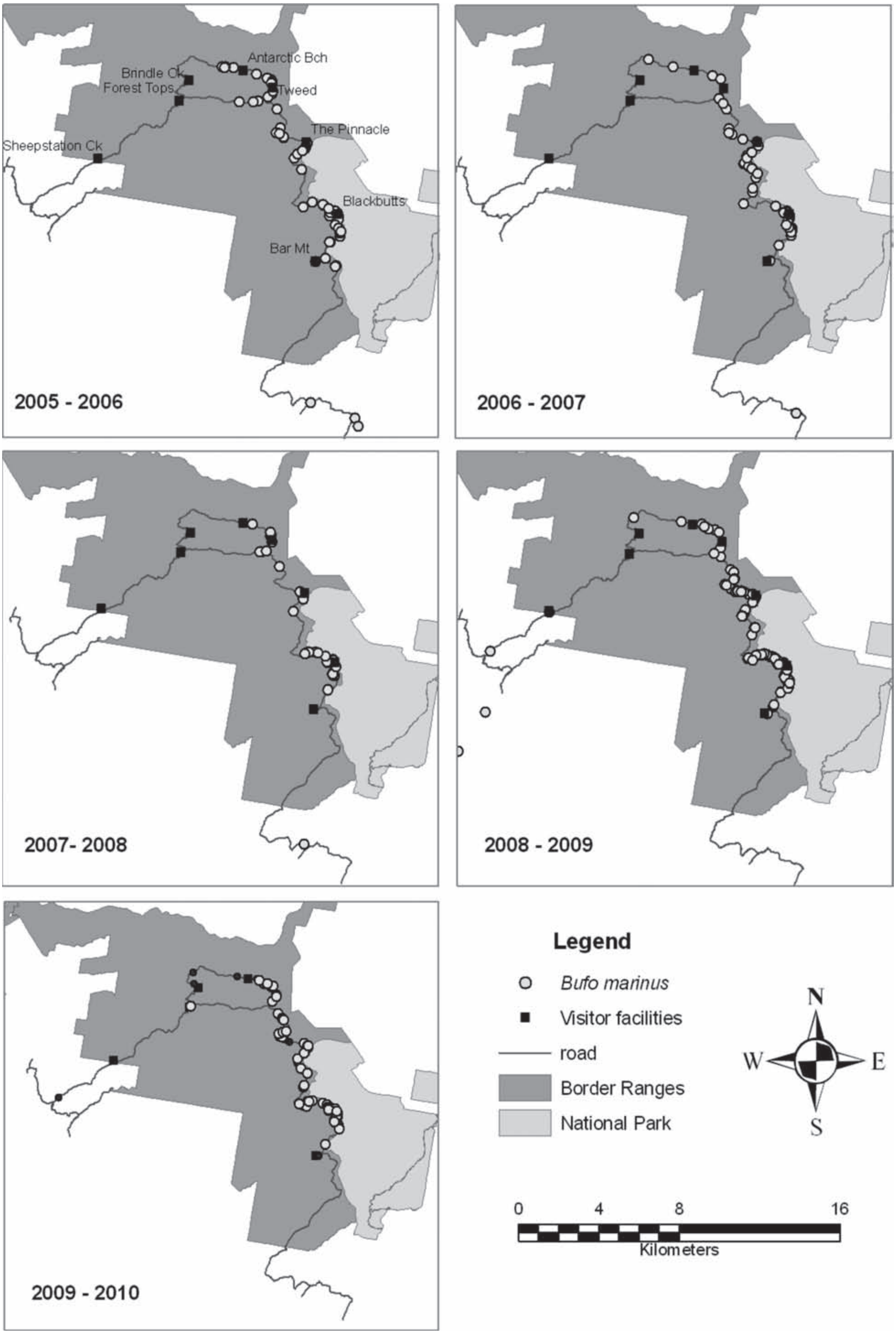
An alternative hypothesis is that they are being translocated. Inadvertent translocations frequently occur in construction materials and the gravel used in road maintenance is one potential source, as is firewood. However, these materials are used throughout the reserve and as such one would expect to find translocated individuals on all road surfaces and around campgrounds. If temperature were limiting their distribution, then this would most likely translate to an absence from the higher elevation areas. Based on the locations of individuals captured to date (with the exception of the one male in 2010), neither statement holds true. The lines of evidence support the notion that toads may have arrived via forest and not roads and that a number of incursion points along the escarpment from the Tweed Valley seem likely, despite the steep nature of these slopes.

Bufo marinus is abundant around water storages (farm dams) in agricultural areas to the east (the Tweed Valley) and these may act as a source for dispersing toads. Sztatecsny and Schabetsberger (2005) radio-tracked common toads (*Bufo bufo*) and found that they were capable of climbing scree slopes of 45° and cliff lines up to 65°. For *B. marinus*, the high quality habitat and lack of competition along the escarpment mean that any risks associated with such a migration are well rewarded. Studies are now required to examine the movement patterns of *B. marinus* into and within these rainforest habitats. These studies are likely to provide considerable insights into development of control strategies and a better understanding of any impacts.

Understanding the impacts

Preliminary spool-tracking shows that *B. marinus* is readily using rainforest (in addition to roads) and that shelter sites within rainforest are used (Newell unpub. data). Whilst some individuals have made large nightly movements along roads, they frequently sheltered within and moved through rainforest. Shelter sites under leaf litter, logs and rocks or within tree buttresses and vegetation are being exploited. These habitats are also important for several species of endemic frog for which there is conservation concern (Hero *et al.* 2006). These include the endangered *M. fleayi* and the Mountain Frog *Philoria loveridgei* in addition to the vulnerable Pouched frog *Assa darlingtoni*.

It is not known what impacts (if any) may occur to native frogs as a result of these recent invasions. *Bufo marinus* may provide a vector for introduced parasites (Delvinquier 1986; Delvinquier and Freeland 1988), and pathogens (Laurance *et al.* 1996; Berger *et al.* 1999; Daszak *et al.* 1999) as well as competing with native species for resources. Murray and Hose (2005) suggested that declines in Australian frogs are correlated with large body size, narrow geographical range and with


Antarctic Bch
Brindle Ck
Forest Tops
Tweed
The Pinnacle
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2005 - 2006
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Figure 4. Location of *Bufo marinus* detected in the Border Ranges World Heritage Area 2005-2010

overlaps in the distribution of *B. marinus*. If correct, this would indicate that there are substantial risks to *M. fleayi* associated with the invasion of *B. marinus* into rainforests of northern NSW. The Border Ranges is an important site for the conservation of this frog in NSW (Goldingay *et al.* 1999).

Impacts on a number of native predators (Covacevich and Archer 1975; Burnett 1997; Phillips *et al.* 2003; Doody *et al.* 2006; Griffiths and McKay 2007; Doody *et al.* 2009) and invertebrates (Greenless *et al.* 2006) may be substantial. It is apparent that many unique species that have not encountered *B. marinus* previously, are now being exposed to this threat. Understanding the impacts will require detailed monitoring to be initiated across a range of species. Fortunately, detailed population monitoring of *M. fleayi* has been conducted since 2000 within the Brindle Creek catchment and will provide an important baseline against which to measure population level responses.

Implications for control

Consecutive nightly surveys were attempted because these were considered to be a more effective means of detection and hence controlling toads. Schwarzkopf and Alford (1996) showed that *B. marinus* was not always active on any given night and that desiccation rates and temperature influenced activity levels. The mean length of time that their radio-tracked toads remained inactive within shelter sites without emerging was three days. During surveys conducted over three consecutive nights in the current study, the number of *B. marinus* captured declined with time, suggesting that most toads (near the road) became active over a three-day period. Desiccation rates and temperature profiles are likely to be different in the rainforests of our study site and this would influence movements and activity levels. Understanding the frequency and timing of movements will have implications for future control efforts.

Schwarzkopf and Alford (2002) suggested that *B. marinus* was largely nomadic and that movement was influenced by seasonal factors that influenced food availability, desiccation and predation risks. These factors vary across the geographic range and the diversity of habitats now occupied by *B. marinus* within Australia and influence invasion dynamics. Urban *et al.* (2008) demonstrated that invasion speed was greatest in areas of heterogeneous topography, low elevations, dense road networks and high patch connectivity. However, time since establishment also appears to dramatically influence movement and dispersal behaviour in *B. marinus* (Phillips *et al.* 2008a; Alford *et al*. 2009). At the invasion front in northern Australia, *B. marinus* behave in remarkably different ways to long established populations and are capable of large nightly movements. Phillips *et al.* (2007) radio-tracked toads and recorded movements up to 22 km over a 30-night period. This accelerated dispersal ability has been attributed to the rapid "spatial selection" at the invasion front (Phillips *et al.* 2008b) that may drive the evolution of morphological traits that favour increased locomotor performance (Phillips *et al.* 2006). This raises the question, are toads in southern regions also adapting to deal with colder climates?

Information is required to determine the thermal constraints placed upon toads at high elevation sites such as the Border Ranges. It is currently unknown if *B. marinus* can survive over winter in these habitats or if it will breed and become permanently established. Shelter sites are available to *B. marinus* that may allow it to maintain sufficient body temperature during winter to survive (Kearney *et al.* 2008). The abundance of invertebrates available may also allow them to feed without having to actively forage. Understanding how toads use these habitats and their thermal tolerances will be important for predicting future distributions, particularly in cooler regions.

It is clear that *B. marinus* is now present in high elevation rainforest habitats, however these areas may be well beyond breeding sites. Opportunities for breeding appear to be limited, with most water bodies associated with rainforest streams. However, in areas of lower elevation rainforest (the Bangalow complexes) there are ample breeding opportunities available (ponds) and these habitats have also been recently invaded within the Nightcap World Heritage Area (Newell unpub. data). Interestingly, only one individual captured within the Border Ranges was readily identifiable as a male and all other captures displayed what are thought to be typically female traits (McKoy *et al.* 2008). In contrast, males detected at farm dams and along roadways (outside of the reserve) were uniformly coloured and did not have a dorsolateral stripe. These toads also had well developed nuptial pads and discolouration of the throat was evident. Further investigation of sexual dimorphism in *B. marinus* is required.

This study provides baseline information on cane toad distribution within the Border Ranges that will be important in identifying areas for ongoing control. The use of manual collection in this study has reduced the number of *B. marinus* detected over short time frames (monthly) and the area occupied has remained stable, despite the dramatic increase in abundance in the 2008-09 season. As such, removals should be continued into the future. However, long-term control is likely to only be successful if the source populations can be controlled. This may be possible through the use of habitat manipulation (see Semeniuk *et al.* 2007) and control at breeding sites on private lands outside of the reserve. Alford *et al.* (2006) suggested that *B. marinus* has relatively low survival rates at breeding sites. As such, rigorous control efforts focused on breeding habitats may be an appropriate method that can lead to population declines. White (2007) reported declines in an isolated population of *B. marinus* at Port Macquarie (NSW) that was attributed to manual collection. This offers hope that manual collection in the Border Ranges National Park may be an effective tool in managing this population.

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References

Alford, R.A., L. Schwarzkopf, G. Brown, B. Phillips, and Shine, R. 2006. Characteristics of *Bufo marinus* in old and recently established populations. In Molloy, K.L. and Henderson, W.R. (Eds) (2006). *Science of Cane Toad Invasion and Control*. Proceedings of the Invasive Animals CRC Cane Toad Workshop, June 2006, Brisbane. Invasive Animals Cooperative Research Centre, Canberra.

Alford, R.A., G. Brown, L. Schwarzkopf, B. Phillips and Shine, R. 2009. Comparisons through time and space suggest rapid evolution of dispersal behaviour in an invasive species. *Wildlife Research* **36**: 23-28.

Berger, L., R. Speare, and Hyatt, A. 1999. Chytrid fungi and amphibian declines: overview, implications and future directions. Pp. 23-33 In *Declines and Disappearances of Australian Frogs*, edited by A. Campbell. Environment Australia, Canberra.

Brown, G. P., B. L. Phillips, J. K. Webb, and Shine, R. 2006. Toad on the road: Use of roads as dispersal corridors by cane toads (*Bufo marinus*) at an invasion front in tropical Australia. *Biological Conservation* **133**: 88-94.

Burnett, S. 1997. Colonizing cane toads cause population declines in native predators: reliable and anecdotal information and management implications. *Pacific Conservation Biology* **3**: 65-72.

Covacevich, J. and Archer, M. 1975. The distribution of the Cane Toad *Bufo marinus* in Australia and its effects on indigenous vertebrates. *Memoirs of the Queensland Museum* **17**: 305-310.

Daszak, P., L. Berger, A. A. Cunningham, A. D. Hyatt, D. E. Green, and Speare. R. 1999. Emerging infectious diseases and amphibian population declines. *Emerging Infectious Diseases* **5**: 735-748.

Delvinquier, B. L. J. 1986. *Myxidium immersum* (Protozoa : Myxosporea) of the cane toad, *Bufo marinus*, in Australian Anura, with a synopsis of the genus in amphibians. *Australian Journal of Zoology* **34:** 843-53.

Department of the Environment and Water Resources (DEWR). 2007. Australia's 15 National Biodiversity Hotspots, Border Ranges North and South (Queensland and New South Wales), Commonwealth of Australia, Canberra

Department of Environment and Climate Change, NSW (DECC). 2008. Preliminary Draft Border Ranges Rainforest Biodiversity Management Plan (NSW & QLD) National Recovery Plan for the Border Ranges Hotspot Region, Department of Environment and Climate Change (NSW), Sydney.

Doody, J. S., B. Green, R. Sims, D. Rhind, P. West, and Steer. D. 2006. Indirect impacts of invasive cane toads (*Bufo marinus*) on nest predation in pig-nosed turtles (*Carettochelys insculpta*). *Wildlife Research* **33**: 349-354.

Doody, J. S., B. Green, D. Rhind, C. M. Castellano, R. Sims, and T. Robinson. 2009. Population-level declines in Australian predators caused by an invasive species. *Animal Conservation* **12**: 46-53.

Esteal, S., E.K., van Beurden, R.B. Floyd, and Sabath, M.D. 1985. Continuing Geographical Spread of *Bufo marinus* in Australia: Range Expansion between 1974 and 1980. *Journal of Herpetology* **19** (2): 185-188.

Easteal, S. and Floyd, R.B. 1986. The ecological genetics of introduced populations of the giant toad, *Bufo marinus*. Dispersal and neighbourhood size. *Biological Journal of the Linnean Society* **27**: 17-45.

Goldingay, R., D. Newell, and Graham, M. 1999. Status of rainforest stream frogs in north-eastern New South Wales: decline or recovery? Pp. 64-71 in *Declines and Disappearances of Australian Frogs*, edited by A. Campbell. Environment Australia, Canberra.

Greenlees, M. J., G. P. Brown, J. K. Webb, B. L. Phillips, and Shine, R. 2006. Effects of an invasive anuran the cane toad (*Bufo marinus*) on the invertebrate fauna of a tropical Australian floodplain. *Animal Conservation* **9**: 431-438.

Griffiths, A. D., and McKay. J. L. 2007. Cane toads reduce the abundance and site occupancy of Merten's water monitor (*Varanus mertensi*). *Wildlife Research* **34**: 609-615.

Hero, J. M., C. Morrison, G. Gillespie, J. D. Roberts, D. Newell, E. Meyer, K. McDonald, F. Lemckert, M. Mahony, W. Osborne, H. Hines, S. Richards, C. Hoskin, J. Clarke, N. Doak, and Shoo. L. 2006. Overview of the conservation status of Australian Frogs. *Pacific Conservation Biology* **12**: 313-320.

Kearney. M.R., B.L. Phillips, C.R. Tracy, K.A. Christian, G. Betts and Porter. W.P. 2008. Modelling species distributions without using species distributions: the cane toad in Australia under current and future climates. *Ecography* **31**: 423 434.

Laurance, W. F., K. R. McDonald, and Speare. R. 1996. Epidemic disease and the catastrophic decline of Australian rainforest frogs. *Conservation Biology* **10**: 406-413.

McCoy, K. A., L. J. Bortnick, C. M. Campbell, H.J. Hamlin, L. J.(Jr) Guillette and St. Mary, C.M. 2008. Agriculture Alters Gonadal Form and Function in the Toad *Bufo marinus*. *Environmental Health Perspectives* **116** (11): 1526-1532.

Mungomery, R.W. 1936. A survey of the feeding habits of the giant toad (*Bufo marinus*) and notes on its progress since introduction into Queensland. *Proceedings of the Queensland Society of Sugar Cane Technologists* **1936**: 63-74.

Murray, B. R., and Hose. G. C. 2005. Life-history and ecological correlates of decline and extinction in the endemic Australian frog fauna. *Austral Ecology* **30**: 564-571.

Phillips, B. L., G.P. Brown, and Shine, R. 2003. Assessing the potential impact of cane toads on Australian snakes. *Conservation Biology* **17**: 1738-1747.

Phillips, B. L., G. P. Brown, J. K. Webb, and Shine. R. 2006. Invasion and the evolution of speed in toads. *Nature* **439**: 803-803.

Phillips, B. L., G. P. Brown, M. Greenlees, J. K. Webb, and Shine. R. 2007. Rapid expansion of the cane toad (*Bufo marinus*) invasion front in tropical Australia. *Austral Ecology* **32**: 169-176.

Phillips, B.L., J.D. Chipperfield and Kearney. M.R. 2008a. The toad ahead: challenges of modelling the range and spread of an invasive species. *Wildlife Research* **35**: 222–234.

Phillips, B.L., G. P. Brown, J.M.J. Travis and Shine. R. 2008b. Reid's Paradox Revisited: The Evolution of Dispersal Kernels during Range Expansion. *The American Naturalist* vol. **172** supplement.

Sabath, M.D., W.C. Boughton, and Easteal. S. 1981. Expansion of the range of the introduced toad *Bufo marinus* in Australia from 1935 to 1974. *Copeia* **3**: 676-680.

Schwarzkopf, L., and Alford. R. A. 1996. Desiccation and shelter-site use in tropical amphibians: comparing toads with physical models. *Functional Ecology* **10:** 193-200.

Schwarzkopf, L., and Alford. R. A. 2002. Nomadic movement in tropical toads. *Oikos* **96**: 492-506.

Seabrook. W. 1991 Range expansion of the introduced cane toad *Bufo marinus* in New South Wales. *Australian Zoologist* **27:** 58-62.

Seabrook, W. A., and Dettmann. E. B. 1996. Roads as activity corridors for cane toads in Australia. *Journal of Wildlife Management* **60**: 363-368.

Semeniuk, M., F. Lemckert, and Shine. R. 2007. Breeding-site selection by cane toads (*Bufo marinus)* and native frogs in northern New South Wales, Australia. *Wildlife Research* **34**: 59-66.

Smith, A. P., H.P Hines and Webber, P. 1989. *Mammals, reptiles and Amphibians of the rainforests of the Mount Warning Caldera Region*. Department of Ecosystem Management, University of New England, Armidale.

Sztatecsny, M., and Schabetsberger. R. 2005. Into thin air: vertical migration, body condition, and quality of terrestrial habitats of alpine common toads, *Bufo bufo. Canadian Journal of Zoology-Revue Canadienne De Zoologie* **83**: 788-796.

Urban, M., B. L. Phillips, D. K. Skelly, and R. Shine. 2007. The cane toad's (*Chaunus marinus*) increasing ability to invade Australia is revealed by a dynamically updated range model. *Proceedings of the Royal Society London* Series B **274**:1413-1419.

Urban, M. C., B. L. Phillips, D. K. Skelly, and Shine. R. 2008. A toad more traveled: The heterogeneous invasion dynamics of cane toads in Australia. *American Naturalist* **171**: 134-148.

Van Beurden, E.K and Grigg, G.C 1980. An isolated and expanding population of the introduced toad *Bufo marinus* in New South Wales. *Australian Wildlife Research* **7**: 305-310.

White, A.W. 2007. Living with *Bufo*. Pp. 81-91 in *Pest or Guest: the zoology of over abundance* edited by D. Lunney, P. Eby, P Hutchings and S. Burgin. Royal Zoological Society of New South Wales, Mosman, NSW.

Zug, G. R. and Zug, P. B. 1979. The Marine Toad, *Bufo marinus*: a natural history of native populations. *Smithson. Contrib. Zool.* **284:** 1 – 5.